Chemical Control of Weeds in Nursery Plantings

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Chemical Control of Weeds in Nursery Plantings

John F. Ahrens

INTRODUCTION

The need for weed control in nursery plantings is indisputable. High costs of operation call for new ways of reducing weed populations that compete with valued plants for fertilizers and water. The use of herbicides is often cheaper, more convenient, and less injurious to nursery stock than the usual hand methods that supplement cultivation.

Selective herbicides now give promise of controlling weeds in crops with a high degree of safety. This situation contrasts sharply with that of a few years ago, when herbicides and techniques of application were not highly selective and the danger of injuring valued plants was great.

Research on chemical weed control was undertaken at this Station about three years ago. During these years, extensive experiments have been in progress, many of them on control of weeds in nursery plantings. This Bulletin reports the experience gained from our experiments, together with the results of experimental evaluations of herbicides on nursery stock elsewhere.

This Bulletin has been written primarily for Connecticut nurserymen. Experience derived from many individual experiments is summarized; results of experiments are not reported in detail. The properties of individual herbicides, their chemical, herbicidal, and other biological properties are discussed in Appendix A. Methods of calibrating equipment for applying herbicides and procedures used for satisfactory application are presented in Appendix B. Information on the tolerance of nursery plants, perennials, and bulbs to herbicides is given in Appendix C.

The desirable application rate for a specific herbicide varies somewhat with the season, the type of soil, the amount of soil moisture, the types of weeds to be controlled and, above all, the species tolerance. In this Bulletin the rates of application (dosages) refer to the number of pounds of active herbicide applied per acre of soil treated. In general, the lower rates are effective on light soils, usually low in organic matter, and are also effective under optimal conditions of soil moisture. Higher rates may be required on soils with a high content of organic matter or when soil moisture is limiting (55). The higher dosages of residual herbicides usually control weeds for longer periods.

THE USE OF HERBICIDES ON ESTABLISHED PLANTINGS

Established plants are those that have grown for one season or more in a single location. These plants have overcome the shock of transplanting and have developed vigorous root systems. Such plants are more resistant to herbicides than are plants that have not become established.

Work at this Station has included yews and maples in established plantings. However, considerable work elsewhere has been conducted in established plantings of many types. The reactions of some of the plants tested are shown in Appendix C.

Treatments For Use During the Growing Season

Herbicides applied when nursery plants are growing actively (mid-spring to early fall) must be applied more selectively than during the dormant season. With some herbicides, sprays or granular formulations must be directed to the weeds and away from the nursery stock. Other herbicides on some species are safely applied as overhead sprays.

The weed species occuring during the spring and summer include annual broadleafed weeds (lambsquarter, pigweed, smartweed, purslane, etc). and annual grasses (crabgrass, foxtail, barnyard grass, etc.) in addition to the winter annuals and perennials (chickweed, groundsel, chrysanthemum weed, quackgrass, etc.).

The annual weeds may be controlled by pre-emergence or post-emergence applications.

Pre-emergence treatments

Pre-emergence herbicides are applied to weed-free soil and act by killing weeds in early stages of germination or growth. Best results with pre-emergence herbicides have been obtained by applying the herbicide as soon as possible after disturbing the soil by cultivating or hoeing. Existing weeds usually are not killed by pre-emergence herbicides.

Woody nursery plants in general are tolerant of most pre-emergence herbicides if applied selectively, i.e., as granular applications or directed sprays. The herbicide treatments listed in Table 1 have controlled weeds for periods of at least 4 weeks in tests conducted in established yews and maple trees at this Station or in nursery plantings elsewhere.

Among the herbicides tested, the triazines (simazine and atrazine) and the substituted urea herbicides (monuron, diuron, and neburon) possess the longest residual activities in the soil. Most of these have proven to be very useful for nursery plantings.

With single applications, simazine, atrazine, and diuron can provide weed control in woody nursery plantings for periods of several months. Of these, simazine appears to be outstanding from the standpoint of controlling weeds without injury to a wide range of nursery species (1,5,11,-42,43). Most annual weeds and some perennial weeds are controlled by simazine, although the control of crabgrass is often poor at low rates of application or under dry soil conditions (5).

Simazine wettable powder is safe for use on many woody species and the granular formulation is even safer (10,24). Dosages as high as 10 lbs.

Table 1. Pre-emergence herbicides tested in established plantings

Compound[1]	Range of dosage lbs./A.	Method of application[2]
Simazine	2 to 4	Spray or granular application
Atrazine	3 to 4	Granular application or directed spray
Diuron	1 to 3	Granular application or directed spray
Neburon	3 to 6	Granular application or directed spray
Monuron	½ to 1	Directed spray
DNBP	8 to 10	Granular application or directed spray
EPTC	4 to 6	Spray or granular application, applied to dry soil and cultivated in
CDEC	9 to 12	Spray or granular application, applied to dry soil and cultivated in
CIPC	8 to 12	Granular application or directed spray
CIPC-sesone	4 of each	Granular application or directed spray
Sesone	4 to 6	Spray application
2,4-DEP	4 to 6	Granular application or directed spray
NPA	4 to 8	Granular application or directed spray

[1] The chemical and biological characteristics of the herbicides discussed in this bulletin are given in Appendix A.

[2] Methods of applying herbicides are discussed in Appendix B.

per acre have not injured a number of established woody plants including varieties of yews, aborvitae, juniper, peonies, roses, ground-cover plantings, and others (40). However, species differ considerably in their tolerances of simazine and many are injured by dosages above 2 to 4 lbs. per acre (11,24). Most herbaceous perennials and several nursery plants, including privet, often are injured by even low dosages of simazine. Lilac is apparently tolerant of simazine but lilac grafts on privet rootstocks are susceptible. Euonymous, azalea species, and forsythia are among a group of plants which appear to be tolerant of low dosages of simazine (2 to 3 lbs. per acre) but may be injured by higher dosages. Because of these species differences and the lack of detailed information on tolerances, the wide-scale use of simazine should be restricted to only those species listed on the commercial label. This is also true of other herbicides.

Under moist soil conditions, simazine at 2 lbs. per acre may lose its herbicidal properties within 8 weeks (46). In dry seasons, it persists for much longer periods. At rates above 3 to 4 lbs. per acre, residual control of weeds usually extends into the fall and the following spring. A reduced rate of application is indicated for the following season where this occurs.

Ample soil moisture after application is essential for the action of all pre-emergence herbicides. This is especially true of insoluble materials such as simazine and neburon. Several observations indicate that a soaking rain or irrigation is essential in the week or two following application of these materials.

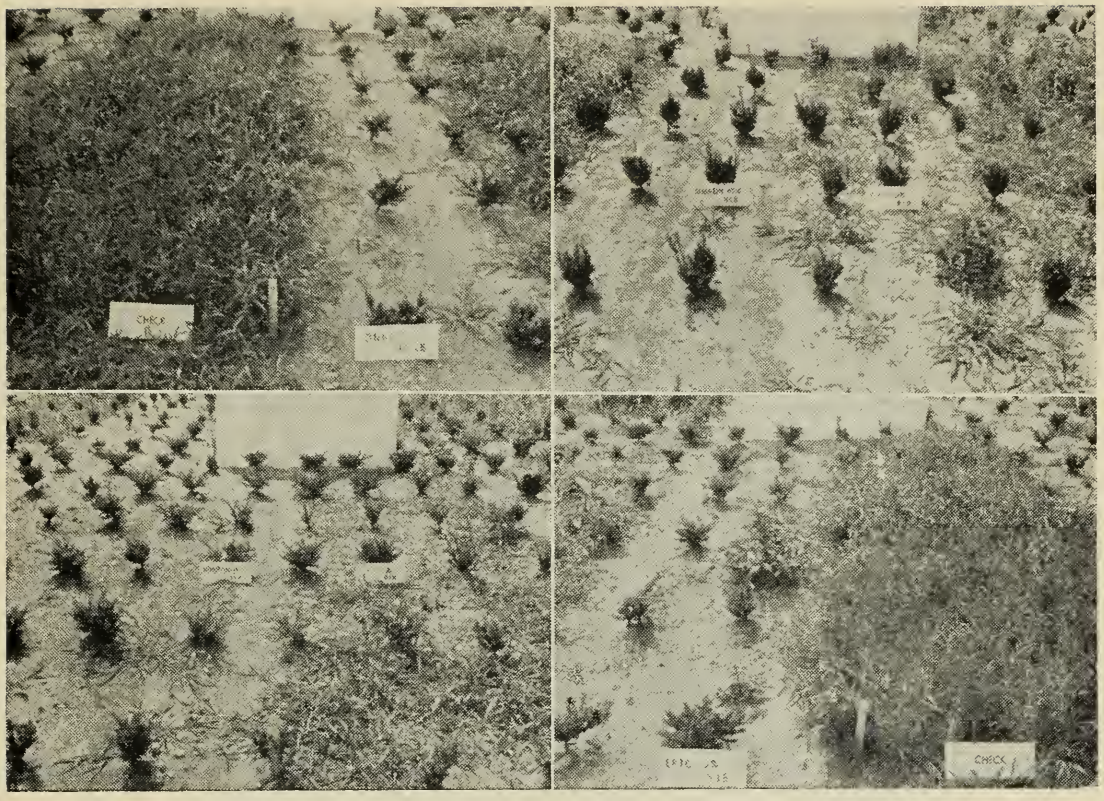

Figure 1. Results following pre-emergence herbicides applied in established taxus liners on June 24 after cultivating and hoeing. Picture was taken 9 weeks later. Top left, control vs. granular DNBP at 12 lbs. per acre; right, granular simazine at 4 lbs. per acre vs. granular CIPC at 8 lbs. per acre. Lower left, neburon wettable powder at 4 lbs. per acre vs. granular CIPC at 8 lbs. per acre; right, granular EPTC at 4 lbs. per acre vs. control.

With the granular formulations, soil moisture is even more critical. Under dry soil conditions, simazine sprays are more effective than granular formulations. According to Lovely (32), the performance of granular simazine during dry periods may be improved where it is incorporated (cultivated) into the soil. However, our results indicate that incorporation of simazine at dosages under 4 lbs. per acre may decrease its effectiveness.

Although dry soil conditions decrease the initial effectiveness of simazine, new seedlings are killed as moisture becomes available. Cultivation and removal of the escaped weeds often is followed by residual control of new weed seedlings (5). Residual weed control after cultivation has been much better with simazine than with most other pre-emergence herbicides.

Despite its long activity in the soil, simazine, used in yearly applications at normal dosages, has not injured yews, many other established plantings, or new plantings of yews or hemlocks following (see page 5). Repeat applications at high dosages within a short period are not only unnecessary, but they may depress growth (1). Occasional discoloration of foliage by high dosages of simazine may be partially overcome by supplemental nitrogen fertilization.

Atrazine, a relative of simazine, has shorter residual activity in the soil, albeit sufficient for seasonal weed control at the higher dosages (11,

21,40,43). Atrazine sprays are toxic to nursery foliage but granular atrazine is reported to be useful on many of the species tolerant of simazine (11,40). Because of its greater solubility, atrazine is often more effective than simazine under dry soil conditions (44). However, atrazine cannot be expected to be as safe as simazine on species of questionable tolerance.

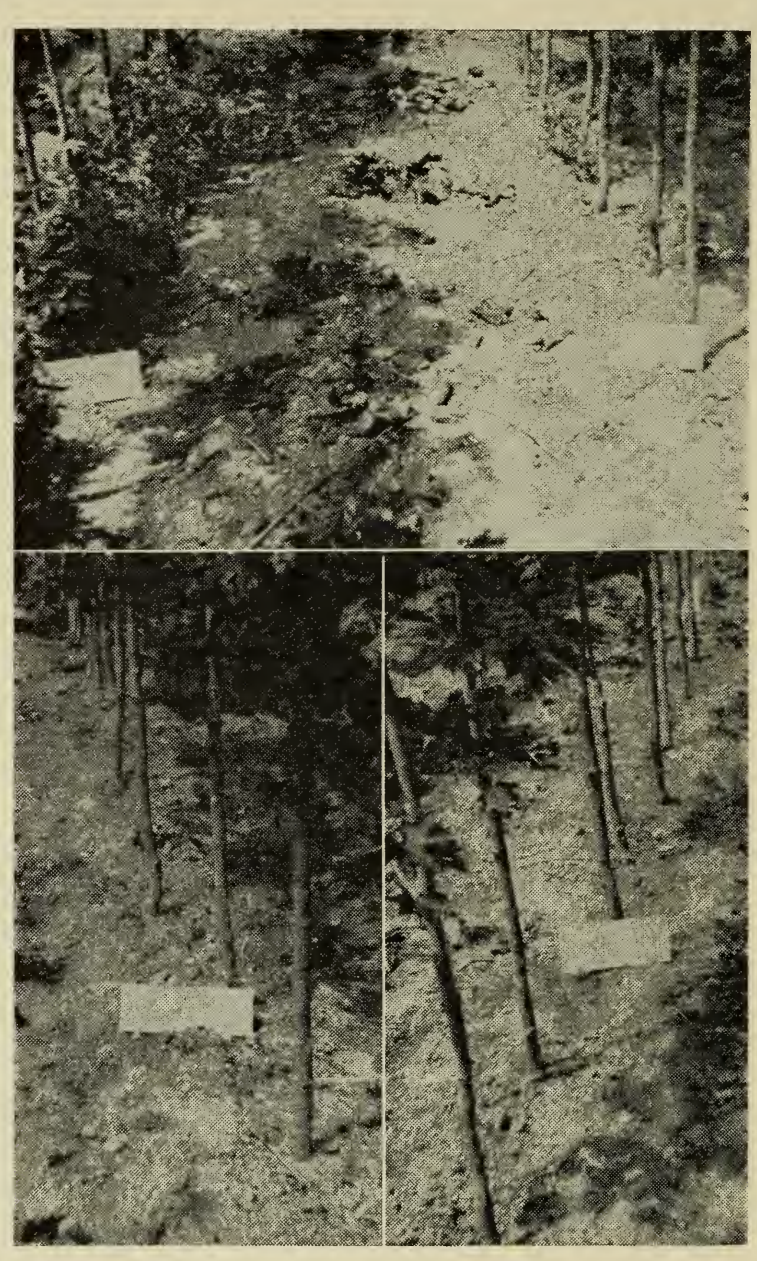

Figure 2. Pre-emergence weed control in maples with directed sprays of herbicides. Plots were hoed in early May before herbicides were applied. Pictures were taken 7 weeks later. Top, control vs. DNBP at 6 lbs. per acre. Lower left, diuron at 2 lbs. per acre; right, simazine at 4 lbs. per acre.

Diuron has been most promising for use in certain deciduous plantings as the granular application or directed spray (2,4,6,8,11,42,48,49). For established evergreens, diuron can be very useful during the dormant season. *Ilex crenta convexa* is highly susceptible to diuron, as are new transplants, most herbaceous plants, and often young established plants, especially in seasons of heavy rainfall (10,11,42). Diuron provides seasonal

control of annual weeds at rates of 3 to 4 lbs. per acre, but the use of diuron at these rates during the growing season is hazardous in many plantings. In one test, liners of taxus were injured by a dosage of 2 lbs. per acre. Applications of diuron at 1½ lbs. per acre have controlled annual weeds for at least 2 months and appear to be safe for use in some nursery plantings, including established yews and hemlocks.

Bailey's work with cultivated blueberries indicates that repeated applications of diuron at dosages of 3 lbs. per acre or above can result in cumulative toxicity (6). Bing also reports that a second annual application of diuron at 1½ lbs. per acre injured *Taxus cuspidata capitata* but that several other plants including rhododendrons, azaleas, and leucothoe were uninjured (9). In our tests, maples were uninjured after two annual applications of diuron at 2 or 4 lbs. per acre.

Neburon has been used for several seasons without injury to many nursery plantings, sometimes at rates of 15 lbs. per acre (35). Neburon is as safe as or safer than simazine on most species, but has shorter residual activity in the soil (11). Under moist soil conditions, however, neburon at 3 to 6 lbs. per acre has provided satisfactory control of annual weeds for 8 to 10 weeks during the spring and summer.

Neburon sometimes causes a temporary discoloration when sprayed on actively growing nursery foliage, but this has not seriously affected growth of yews (13). Generally fair to poor weed control has been reported with granular formulations during the growing season (43). In tests at this Station, granular neburon has been effective only where adequate rainfall or irrigation followed soon after application. Even then, the results obtained were poorer than those obtained with neburon wettable powder.

Although neburon does not create a problem of toxic residues in the soil, repeat applications at high dosages within short periods are usually unnecessary and may depress growth in some species (1).

Monuron offers the same weed killing potential as diuron but is more soluble and hence more hazardous for use in nursery plantings except at very low dosages. Therefore, the residual weed control obtained with single applications may be shorter than that obtained with diuron or neburon. Monuron is not currently available in granular form and must be used as a directed spray. Work of Ticknor and Bobula in Massachusetts and others indicates that monuron can be used at ½ to 1 lb. per acre in certain established nursery plantings, including yews, junipers, cotoneasters, and rhododendrons (47,49,50,51). Monuron also has been useful in controlling weeds around young apple trees at higher rates of application (28). For use in most nursery plantings, however, monuron is more hazardous and offers no advantages over other pre-emergence herbicides.

Oats and other cover crops seeded in the fall may be affected by spring applications of long residual herbicides. Spring applications of simazine at rates above 3 lbs. per acre or diuron at rates above 2 lbs. per acre have inhibited the growth of oats in September.

Where winter erosion is a problem, seasonal control of weeds with herbicides may not be desirable. By applying such herbicides as simazine,

atrazine, or diuron at moderate rates during the winter, after the cover crop is killed by frost, or during the spring, injury to fall cover crops can be avoided. To obtain a maximum degree of weed control and still maintain a winter cover, it may also be desirable to use herbicides of shorter residual activity during the summer months and long residual herbicides during the dormant season.

Spring applications of other pre-emergence herbicides (CDEC, CIPC, DNBP, neburon, NPA, sesone, and 2,4-DEP) with activities in the soil ranging from 1 to 3 months, have not affected oats seeded in the fall. However, late summer applications of most pre-emergence herbicides may affect cover crops of oats. Levels of herbicide in the soil that are toxic to oats are often detected by the absence of annual weeds in treated areas.

DNBP as a directed spray or granular application has been used without injury in many nursery species (1,4,5,12,17). Contact sprays of DNBP are toxic to seedlings of broadleafed weeds as well as germinating weed seeds, but DNBP does not accumulate in the soil. Repeat applications of granular DNBP at rates up to 12 lbs. per acre within periods of 2 months have not injured established liners (1).

DNBP is most active against annual broadleafed weeds. Under conditions of moist soil and at rates of 9 to 10 lbs. per acre, DNBP has controlled broadleafed weeds and grasses for periods of 8 to 10 weeks. However, at rates of 5 to 6 lbs. per acre, the control of grasses with DNBP has been relatively short-lived. Annual grasses ordinarily do not present a problem until late spring and they are most troublesome during the summer. For this reason, DNBP has been most useful in late winter or spring applications.

When incorporated into the soil, EPTC at 4 to 6 lbs. per acre controls weeds for periods of 6 to 10 weeks. Work at this Station and elsewhere has shown that established yews, hemlocks, and many other nursery plants are tolerant of these rates of EPTC applied in granular form. EPTC sprays also are reported to be non-toxic to some nursery species (42). At high dosages (8 lbs. per acre) applied annually or in repeat applications within periods of 2 months, however, EPTC has caused a depression of growth in yews (1).

EPTC is active mainly against annual grasses and also has shown promise for controlling perennial weeds such as quackgrass and nutgrass (18,55). Certain broadleafed weeds such as smartweed are not controlled by EPTC. Havis, Ticknor, and Bobula (25) have shown that EPTC is most effective when applied to dry soil and followed by cultivation or irrigation. EPTC, therefore, works well during the summer in combination with cultivation.

CDEC appears to be non-toxic to nursery plantings, either as a spray on some species (42) or in granular form. Single applications at rates as high as 40 lbs. per acre have not injured yews or junipers (52), and repeat applications within the same season have not injured yews (1). Like EPTC, CDEC works best when incorporated into dry soil (25) and is most effective against grassy weeds. However, CDEC does not control broadleafed weeds as well as EPTC and has been somewhat erratic in performance. For these reasons, CDEC does not appear very promising for use in established nursery plantings.

Granular CIPC has been used at rates as high as 32 lbs. per acre without injuring many established and newly planted woody species (9). Lower rates of application (6 to 8 lbs. per acre) also have been used with success on many perennial plants (7). Homeowners may find CIPC useful for the control of dodder (*Cuscuta* spp.) in chrysanthemums and other perennial plantings. Although most woody nursery plants are tolerant of CIPC, injury has been reported with the azalea variety Hinodigeri (*A. obtusum,* var. hinodigeri), and privet (*Ligustrum* spp.) (7). The miscible formulation of CIPC is toxic to actively growing foliage of some nursery plants. Repeated applications of CIPC, when necessary during the season, have not affected tolerant species.

CIPC, at rates of 8 to 12 lbs. per acre, controls annual grasses and many broadleafed weeds for periods of 6 to 10 weeks or more. Certain broadleafed weeds, such as galinsoga *(Galinsoga parviflora),* henbit *(Lamium amplexicaule),* and fleabane *(Erigeron* spp.) are resistant to CIPC. During the spring or summer, the combination of CIPC at 4 lbs. per acre with sesone at 4 lbs. per acre is often more effective against mixed weed species than CIPC alone at 8 lbs. per acre (1).

CIPC is usually effective for longer periods after spring application than after summer application because high temperatures accelerate volatility and loss of herbicidal activity.

Sesone has been widely tested for use in nursery plantings, perennials, and bulb crops (7,20,30). Most perennial and weedy plants are reported to be tolerant of sesone which often is applied repeatedly during the season.

Sesone, at 4 to 6 lbs. per acre, controls annual weeds for relatively short periods of 4 to 6 weeks (7). Control may persist for longer periods where susceptible broadleafed weeds are dominant (see Table 2, page 12), but control of grasses is short-lived. Combinations of sesone with CIPC have greatly extended the duration of residual weed control. Sesone controls galinsoga, fleabane, and other broadleafed weeds not controlled by CIPC. Applications of sesone on soil that is weed-free and moist have given best results (30).

2,4-DEP is similar to sesone in structure and activity but appears to be more effective against grasses than sesone. At 8 lbs. per acre 2,4-DEP has not injured yews or hemlocks in our tests but 2,4-DEP has not been widely tested in other species. There has been no evidence of injury on yews or hemlocks with repeated applications of 2,4-DEP over a 2-year period.

NPA at 4 to 6 lbs. per acre usually controls annual weeds for monthly periods. As a granular application or directed spray, NPA is extremely non-toxic to woody plants, and may also be used repeatedly during the season in many species (1,42). Because of its short residual effect, however, NPA is not as useful in established plantings as are the more active herbicides.

EPTC and simazine are not usually affected by shallow cultivation provided untreated soil is not thrown into the treated areas. Atrazine and diuron also have residual activity against weeds following cultivation. In areas treated with CIPC, sesone, DNBP, or NPA, however, disturbance of soil by cultivation usually decreases greatly the effectiveness of the herbi-

cide. Cultivation of the row middles when necessary, without disturbing treated areas in the row, is a preferred practice.

Lateral movement of pre-emergence herbicides from treated to untreated areas has seldom been a problem even with the more soluble compounds. But injury has been reported with sesone, for example, as a result of heavy rains causing settling of the herbicide into low spots (20). With the more insoluble herbicides such as simazine, atrazine, diuron, neburon, and CIPC, the likelihood of lateral movement is decreased. However, in sloping areas, and in very heavy rains, where erosion occurs, any herbicide can be moved, and subsequent injury to susceptible plants downslope can result.

Post-emergence treatments

An alternative method of chemical weed control eliminates the need for initial hoeing and cultivating. Herbicides can be used to kill the existing weeds in nursery plantings in addition to providing residual weed control. Treatment involves the application of directed sprays of the herbicides, taking special precaution to avoid hitting foliage. The technique is easily applied in upright deciduous plantings but also has been used with success in upright evergreens.

Table 2. Post-emergence weed control in Crimson King maples with directed sprays

Treatment	Rate lbs./A.	Weed Control: Percentage control of existing weeds 2 weeks[1]	Weed Control: Percentage control of existing weeds 4 weeks[2]	Weed Control: Residual weed control (weeks)[3]	Effects on maple trees
Dalapon	4	0	53	....	None
	8	0	52	....	Severe injury to young leaves and stunting
Amitrol (AT)	3	47	96	7	None
	6	60	99	8	None
DNBP+AT	6+3	99	99	9	Slight injury to young leaves
DNBP+dalapon	6+4	83	98	8	None
Simazine+AT	4+3	100	100	17+(seasonal control)	None
Simazine+dalapon	4+4	90	100	17+(seasonal control)	Moderate injury to young leaves
Diuron+AT	2+3	100	100	12	None
Diuron+dalapon	2+4	97	100	12	Moderate injury to young leaves
EPTC+AT	4+3	43	99	7	None
EPTC+dalapon	4+4	17	57	....	None
Weedy controls	.....	0	0	....	None

[1] Based on visual comparison with untreated control plots.

[2] Based on fresh weights of weeds harvested from treated plots in comparison with untreated control plots. Weeds present at time of treatment were mainly lambsquarter, pigweed, and chickweed.

[3] Based on visual comparison with control plots hoed at time of treatment.

Established chickweed is killed by several herbicides, including compounds ordinarily used for pre-emergence weed control. Among these are simazine, neburon, atrazine, diuron, CIPC, and DNBP. With the exception of neburon and simazine, these materials must be applied as directed sprays to avoid injury on most nursery plantings. DNBP is also quite useful where other broadleafed weeds predominate, but is not effective against established grasses. Atrazine and diuron are effective against seedling grasses and broadleafed weeds.

Amitrol and dalapon also have been tested for post-emergence use in nursery plantings. Amitrol at 1 to 4 lbs. per acre kills many annual and perennial weeds and grasses. Dalapon at 4 to 8 lbs. per acre is effective mainly against grasses.

Tests including amitrol and dalapon applied alone and in combination with pre-emergence herbicides have been conducted at this Station (2,4). The results of one trial are shown in Table 2. Dalapon alone only stunted the broadleafed weeds but combinations of dalapon with simazine, diuron, or DNBP caused a rapid and complete kill. The slow kill of weeds with amitrol was greatly accelerated by adding DNBP, simazine, or diuron. However, EPTC did not enhance the killing power of either amitrol or dalapon, and DNBP did not add greatly to the residual weed control obtained with amitrol alone. Residual weed control was longest with the combinations including simazine or diuron. From the standpoint of long residual weed control with no plant injury, the amitrol-simazine combination was most promising. This combination and the amitrol-diuron combination did not injure maples after a second annual application. Work elsewhere has shown that amitrol-simazine combinations are safe for use in a number of nursery plantings. Because of the small amount of amitrol required in the mixture, the combination can probably be used on most species tolerant of simazine alone, provided directional sprays are used.

The injury which may result from dalapon at high rates of application or in combination with other herbicides in wet seasons like those of 1959 and 1960 is also shown in Table 2. Similar injury has been observed by other workers (14). However, this injury was not damaging to growth except at the high (8 lbs. per acre) rate of dalapon. Repeat applications of dalapon and dalapon-DNBP combinations in 1958, a drier season, had no effect on maples (2). Dalapon-DNBP combinations have shown promise for good weed kill and reasonably long residual control. Dalapon combinations with simazine and diuron require further evaluation before their safety can be adequately assessed for nursery use.

Other work has indicated that the dosages shown in Table 2 are not necessarily the most practical. Because of the combined effects of two types of herbicides in killing existing annual weeds, lower amounts of amitrol or dalapon are often effective. Amitrol at 1 to 2 lbs. per acre and dalapon at 3 to 4 lbs. per acre are usually sufficient when combined with a pre-emergence herbicide.

Residual weed control, on the other hand, is largely determined by the activity of the pre-emergence herbicide in the treatment and the rate of application chosen will depend upon plant tolerance and the residual weed control desired. Application of 3 to 4 lbs. of simazine per acre pro-

vides seasonal control of most annual weeds and is safe for use on many woody plants. DNPB at 9 to 10 lbs. per acre also is safe for nursery plantings and will provide 8 to 10 weeks or more of satisfactory weed control where broadleafed weeds are predominant. Diuron, on the other hand, provides seasonal weed control at rates of 3 to 4 lbs. per acre, but probably should be used at rates of 1 to 2 lbs. per acre for maximum safety during the growing season. At these rates, diuron controls annual weeds for periods up to 3 months.

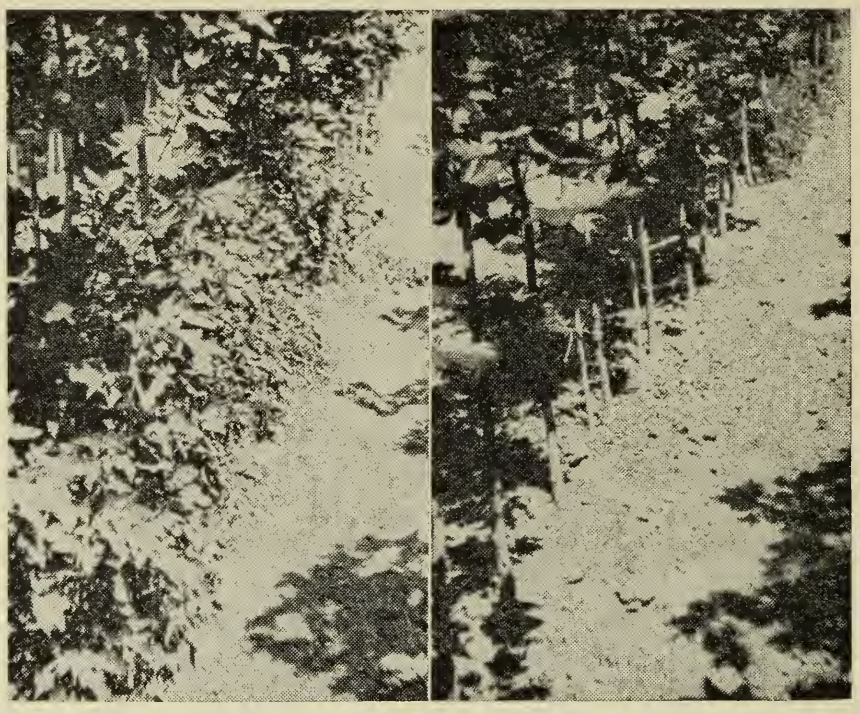

Figure 3. Post-emergence weed control in maples with directed sprays of herbicides. Weeds were sprayed in early May when 4 to 6 inches tall. Pictures were taken 7 weeks later. Left, control; right, simazine at 4 lbs. per acre plus amitrol at 3 lbs. per acre.

In applying post-emergence herbicides in directed sprays, a sufficient volume of spray must be used to wet the weed foliage thoroughly. Excessive rundown at the base of the nursery plants may produce harmful effects.

Amitrol causes severe discoloration, stunting, and sometimes death of nursery plants when sprayed on their foliage. Dalapon produces less striking but also damaging results on nursery foliage. Neither compound affects woody plants through the bark.

Treatments for perennial weeds

Certain perennial weeds are difficult to eliminate from nursery plantings by mechanical means alone. Combinations of cultural and chemical treatments can solve some of these problems.

Chrysanthemum weed *(Artemisia vulgaris)* has been controlled in nursery plantings with directed sprays of amitrol at 4 to 8 lbs. per acre, applied to young regrowth after cultivation or hoeing (43). Repeat applications may be necessary.

Nutgrass *(Cyperus esculentus)* has been controlled in field crops by pre-emergence treatment with EPTC or atrazine at 4 to 6 lbs. per acre worked into the soil following application (18). Directed sprays of atrazine also are effective on young emerged nutgrass, whereas sprays of amitrol and dalapon may not kill but will inhibit growth of nutgrass. Where stands of nutgrass are thick, however, it is probable that yearly applications of herbicides will be required to obtain commercial control. Many woody plants are tolerant of the above herbicides applied as granular formulations or directed sprays.

Quackgrass *(Agropyron repens)* is a persistant perennial weed that may be easier to prevent than it is to control. Although chemical treatments have been used to control quackgrass with pre-planting treatments in annual crops, relatively little has been done in established nursery plantings. Some success has been reported with simazine and atrazine in nursery plantings, at dosages of 4 to 5 lbs. or more per acre (39,44). Havis reports that fall applications of simazine at 3 lbs. per acre greatly weakened stands of quackgrass (24). Other herbicides which can be expected to provide a measure of control of quackgrass in nursery plantings are as follows:

a) dalapon at 6 to 8 lbs. per acre
b) amitrol at 6 to 8 lbs. per acre
c) EPTC at 5 to 6 lbs. per acre
d) combinations of simazine at 4 lbs. per acre and dalapon or amitrol at 4 lbs. per acre.

Our tests indicate these treatments are safe for use in established yews and maple trees, if sprays are directed to avoid hitting the nursery foliage. EPTC and simazine have been used as overall sprays on yews (42).

With dalapon, amitrol, or combinations of these herbicides with simazine, best results can be expected by applying the herbicides on actively growing quackgrass (19,41). After waiting 10 days to 2 weeks to allow translocation of the herbicides to the roots, repeated cultivation or hoeing will further weaken the stand.

Atrazine or simazine may be applied on actively growing quackgrass or on the soil surface after thorough tillage of the quackgrass. EPTC performs best when applied on previously tilled soil and incorporated into the zone of quackgrass root growth (56). Repeat applications may be required for adequate control of quackgrass.

Treatments For Use During the Dormant Season

Nurseries are often choked by weeds in the early spring because cultural practices are neither convenient nor feasible during the fall and winter. Herbicides are often the only means of controlling weeds invading nursery plantings in the late fall and early spring. Because they eliminate the need for hoeing in the early spring, dormant applications of herbicides can be most beneficial to the nurseryman. In addition, dormant applications are often safer and easier to apply. Nursery plants in general are tolerant of higher rates of herbicides during the dormant season, probably because some breakdown and leaching of herbicide occurs, leaving smaller amounts of herbicide in the soil when active

growth of nursery plants begins. The danger of foliage injury with sprays of certain herbicides also is lessened during the dormant season, especially in deciduous and perennial plantings.

Slope and erodibility of the land are factors to be considered in the application of herbicides during the fall. Where erosion occurs herbicide loss also occurs, resulting in possible injury to plants downslope. Erosion and herbicide movement are minimized where a cover crop has been seeded in the fall.

Problem weeds during the fall and early spring in nurseries are mainly winter annuals and some perennials. They have been controlled with herbicides applied in fall, winter, or spring before or after the weeds have emerged.

Pre-emergence treatments

Many of the herbicides suitable for use during the growing season are effective for preventing the invasion of fall weeds. However, only a few of those tested have maintained weed-free conditions in the spring after late fall or winter applications.

Bing (8) reported that seasonal weed control the next year was obtained with the following treatments applied in peony plantings in December:

a) simazine at 10 lbs. per acre
b) neburon at 8 lbs. per acre
c) diuron at 4 lbs. per acre

Lower rates of diuron, simazine, or neburon controlled weeds for part of the season and would be more practical for most growers. In Bing's tests, fall applications of CIPC at 8 lbs. per acre, DNBP at 4 lbs. per acre, and CIPC-sesone combinations resulted in poor control of weeds by spring.

Chadwick applied several herbicides on November 1 in *Taxus cuspidata intermedia* and obtained satisfactory control of weeds until June with simazine at 2 or 4 lbs. per acre (15). CIPC at 8 lbs. per acre controlled about 60 per cent of the weeds until May. The yews were unaffected by the treatments.

On the basis of these and other results, the most promising treatments for application on tolerant species in the late fall or early winter would appear to be simazine or atrazine at 2 to 4 lbs. per acre, diuron at 1½ to 3 lbs. per acre, neburon at 4 to 8 lbs. per acre, and CIPC at 8 to 10 lbs. per acre.

Even in granular formulation, some of the above treatments are known to be active against established chickweed and seedlings of groundsel and annual bluegrass. If the weeds emerge in the fall and are not treated until spring, however, post-emergence sprays with amitrol or dalapon may be required for adequate kill. Established chickweed is an exception in that it is sensitive to the pre-emergence herbicides mentioned above.

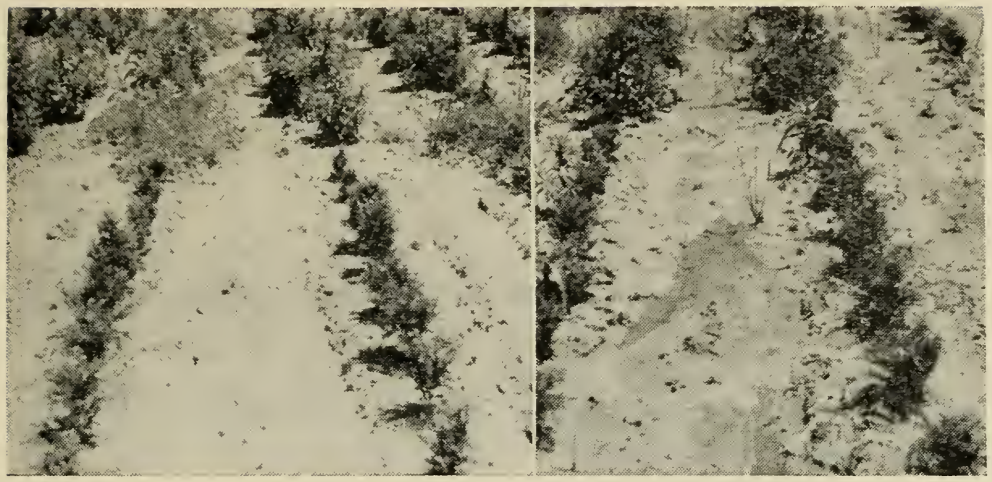

Figure 4. Dormant treatment with granular simazine at 3 lbs. per acre (left) and granular DNBP at 10 lbs. per acre (right) 11 weeks after applications made on March 22. Control plots, infested with fleabane, are shown in the background. Row middles were cultivated in May.

Predominant weed species are important in determining the usefulness of CIPC in fall or winter applications. Fleabane (*Erigeron* spp.) is resistant to CIPC but is controlled with diuron, neburon, atrazine, or simazine. Fleabane, a weed of abandoned fields and waste places, emerges in the fall and spring. Infestations of fleabane can be kept down by cleaning up areas surrounding the nursery plantings.

Other specific weeds which may limit the usefulness of CIPC are galinsoga (*Galinsoga* spp.) and henbit (*Lamium amplexicaule*). Because of its usefulness over a wide range of woody and herbaceous perennial plants, however, CIPC deserves serious consideration for dormant application.

Fall cover crops aid in reducing the invasion of fall weeds. If a cover crop of oats is sown in the fall, herbicide application can be delayed until the oats have grown sufficiently or until after hard frosts kill the oats.

When fall weeds have been kept down, early spring applications of pre-emergence herbicides can greatly reduce weed populations during the critical season. In addition to the herbicides mentioned for use in the fall, DNBP and CIPC-sesone combinations also have been effective (1). Spray applications of DNBP at 6 to 9 lbs. per acre are effective against established chickweed, other weed seedlings, and germinating weed seeds. Lower rates (2 to 4 lbs. per acre) kill chickweed but do not maintain the long residual control desired. Granular applications of DNBP are effective mainly as pre-emergence treatments. Dormant yews are not affected by DNBP in either the granular or spray formulations.

Combinations of CIPC and sesone have shown promise for use in late winter or early spring before weed emergence. This combination effectively controls fleabane, chickweed, and other weeds emerging in early spring.

Post-emergence treatments

Established weeds can be killed during the fall or early spring with the treatments described on pages 12 to 14. Dormant post-emergence

treatments differ from post-emergence treatments applied during periods of active growth in that they are often safer to apply. For example, dalapon and DNBP sprays have been applied overhead in dormant yews without injury, whereas directed applications are required during active growth. The dalapon-DNBP combination has been effective in early spring for killing existing weeds and maintaining 6 to 8 weeks or more of residual weed control.

THE USE OF HERBICIDES ON NEWLY PLANTED NURSERY STOCK

Weeds present special problems in plant beds and lining-out stock because of the close spacing of plants. Although young transplants are characteristically susceptible to chemical injury, herbicides have been used successfully both before and after transplanting.

Lining-out stock refers to plants grown at close spacing in the field, usually following a period of growth in plant beds.

Treatments For Use Before Planting

Treatment of the soil before planting is a common practice in the preparation of plant beds. In some instances, herbicides can also be used for preparation of field planting sites.

Treatments applied to planting beds

Weed control prior to seeding or setting plants into beds can be accomplished by soil fumigation procedures, some of which kill organisms as well as annual and perennial weeds and weed seeds. Fumigation is usually done in the spring or the fall, depending upon the earliness of planting in the spring. Soil temperatures above 50° F. are essential for best results. Because of windblown weed seeds, treatment too long before planting results in poor weed control after planting. Even under optimum conditions, however, seasonal control of weeds cannot be expected from soil fumigants.

In tests conducted at this Station by Gordon S. Taylor, and elsewhere, methyl bromide has been superior to other fumigants, albeit more hazardous to apply (53,54). A poisonous gas, methyl bromide must be tightly sealed with a plastic cover for 24 to 48 hours. After removal of the cover, safe plantings of nursery stock have been made within 1 to 2 weeks (53). However, carnations are reported to be susceptible to injury from methyl bromide.

SMDC and DMTT have been equally satisfactory for weed control in the Northeast, although not quite as effective as methyl bromide (53,54). At least 2 weeks or more must be allowed between treatment and planting to avoid injury to nursery plants (38,53).

Drenches or granular applications of SMDC and DMTT, worked into the soil, are usually sealed with water without the use of a plastic cover. However, Pieczarka and Warren report that with several soil fumigants, including SMDC, weed control was improved by applying a polyethylene cover after treating (34). The combined use of a drench plus a cover gave best results. According to Pridham DMTT also was effective when covered after application (38).

Allyl alcohol, which has been more erratic in performance than SMDC and DMTT, as a drench (53), was very effective when covered with plastic after application (34). Successful plantings of nursery stock have been made within 2 weeks of treatment with allyl alcohol in the spring (53).

The actual time required between fumigation and planting depends largely upon temperature and aeration. Under cool, moist, soil conditions, loss of the fumigants by volatilization is slower, and longer periods should be allowed.

The possible use of pre-emergence herbicides before planting rooted cuttings into beds has been explored only briefly. Massachusetts workers found that EPTC at 10 lbs. per acre, applied 10 days before planting and rototilled into the soil, was effective for weed control without injuring the plants (54). However, these plants (*Rhododendron, Thuja, Taxus* and *Euonymous* species) were growing in 2-inch bands and were not transplanted "bare-root." Our work indicates that bare-root taxus cuttings and other transplants are more sensitive to EPTC and lower rates of application may be necessary. Taxus liners and rooted cuttings were injured by EPTC at 8 lbs. per acre applied 7 to 10 days before planting, but none was injured by EPTC at 4 lbs. per acre or by application 4 weeks before planting. EPTC at 4 lbs. per acre lost its toxicity to tobacco transplants within 3 weeks after application but caused severe injury after 2 weeks.

Treatments applied to field planting sites

Where fields are infested with noxious perennial weeds such as quackgrass, chrysanthemum weed, or nutgrass, etc., it is desirable to eradicate the weeds before planting nursery stock. Because of expense, fumigation treatments suitable for use in plant beds seldom are used in the field. Although a season's fallow with occasional disking will do much to weaken the stands of perennial weeds, herbicides often can be used to good advantage.

All of the herbicides mentioned under *Treatments For Perennial Weeds* can be used in the year preceding planting of woody nursery stock with a minimum of risk. When used in the season before planting, higher rates of application are used, and more effective control may be achieved. With some herbicides, treatments may be applied in the spring of the planting year. However, fall applications should be considered where liners are planted in early spring.

The short-lived effects of dalapon and amitrol in the soil are well established. Work with corn indicates that plantings can be safely made 4 to 6 weeks after application of these herbicides in the spring for control of quackgrass (29,41,56). However, fall applications of amitrol at 6 to 8 lbs. per acre or dalapon at 12 to 15 lbs. per acre on actively growing quackgrass also have been effective (29,56).

Even the longer-lived pre-emergence herbicides such as simazine or EPTC may be safe for use to control certain perennial weeds before planting, as shown in Table 3. In this and another test (5), simazine, which is active in the soil for very long periods, did not affect taxus or hemlock liners planted 1 week after application at 6 to 8 lbs. per acre. At the ex-

tremely high rate of 24 lbs. per acre, simazine injured but did not kill most of the new liners. Dosages of 5 to 8 lbs. of simazine per acre are required for control of quackgrass. Greenhouse tests at other Stations indicate that other species are more sensitive than yews and longer periods may be necessary between treating and planting (40).

Table 3. Effects of incorporating herbicides into root zone before transplanting

Treatment	Rate lbs./A.	Foliage discoloration and/or stunting		Percentage Weed Control[1]			
				7 weeks (first crop)[2]		13 weeks (second crop)[3]	
		Taxus cuspidata capitata	*Tsuga canadensis*	Bdlf.	Grass	Bdlf.	Grass
Controls	....	none	none	0	0	0	0
Neburon	4	none	none	85	33	61	33
	12	very slight	none	98	88	100	95
EPTC	4	none	none	77	96	0	0
	12	very slight	slight	96	99	0	49
CDEC	8	none	none	78	49	0	22
	24	slight	slight	97	95	0	67
Simazine	8	none	none	93	33	83	74
	24	slight	moderate	100	96	100	97

[1] Based on fresh weights of weeds harvested from plots.

[2] Weed population in control plots, 70% Broadleaf, 30% Grasses.

[3] Weed population in control plots, 15% Broadleaf, 85% Grasses.

It was observed that simazine at 4 lbs. per acre lost its toxicity to susceptible tobacco transplants within 2 weeks of application on the soil surface, probably because of soil dilution. Further tests to determine the usefulness of simazine and related compounds for pre-planting treatments to control quackgrass are under way.

EPTC also failed to injure taxus and hemlock liners planted a week after application at 4 lbs. per acre (Table 3), (5). However, at rates of 8 to 12 lbs. per acre, EPTC injured both species. Rates of 4 to 6 lbs. per acre are reported to be sufficient for the control of quackgrass or nutgrass (18,56), although repeat applications may be necessary.

The effects of some pre-planting treatments on the residual control of annual weeds are also shown in Table 3. About 75 per cent control of weeds represents a satisfactory level. Therefore, most of the treatments controlled weeds for 7 weeks after planting and some residual control of weeds was evident in the stands of weeds following.

The advantage of treatment before planting is ease of application. The disadvantages include the higher cost, because the entire area would have to be treated, and the greater possibility of injury to nursery plants by putting the herbicides closer to the roots. For the control of annual weeds in the field, the disadvantages of applying herbicides before transplanting appear to outweigh the advantages. Effective and more economical control of annual weeds can be obtained by disking just prior to transplanting and by the application of pre-emergence herbicides after transplanting.

Treatments For Use After Planting

Directed application is especially important in the successful use of herbicides in new plantings. Transplants with characteristically sparse root systems are very sensitive to herbicide injury. By applying the herbicide on the soil surface, initial contact between herbicide and roots is avoided. The herbicide then is diluted or decomposed sufficiently so that when roots are contacted, injury is avoided.

A combination of factors often determines the outcome with any given herbicide in new plantings. Sufficient time and rainfall for settling soil around roots before herbicide application can avoid channelling of the herbicides to root zones. On the other hand, heavy rainfall soon after application may leach some herbicides to root zones with resultant injury. Leaching varies considerably with soil texture, occurring more readily in the sandy soils. Possible foliar injury and rundown of spray material along the stems to the roots can be avoided by the use of granular formulations. Granular formulations are usually safer than sprays, but especially in newly planted stock.

Transplants of different ages vary in susceptibility to herbicides. Rooted cuttings and small seedlings are apparently more susceptible than larger transplants. This may be due partially to the depth of the roots in relation to the placement of the herbicide.

Treatments applied to planting beds

The relatively short-lived pre-emergence herbicides have been used most successfully in plant beds under widely varying conditions and with many plant species. Low dosages of long residual herbicides may also be useful.

Sesone has been used at 2 to 6 lbs. per acre with no injury on several plant types, including species of yew, holly, euonymous, arborvitae, juniper, pine, spruce, and ground covers of myrtle, pachysandra, and English ivy (26,30,36). Although weed control usually lasts only 4 to 6 weeks, Herron found that three applications in one season on *Taxus media hicksi* costs 33 per cent less than hand weeding (27). This included costs of the weeding required before each herbicide application.

Herron reported that NPA caused no injury to newly planted yews in beds when applied up to three times in one season at dosages of 4 to 8 lbs. per acre (26). Repeat applications every 4 to 6 weeks are usually required for satisfactory weed control. Granular NPA would not cause the foliage injury caused by NPA sprays.

Granular applications of DNBP at 5 to 9 lbs. per acre and CIPC at 8 lbs. per acre are reported by Chappell (16) and Harrison et al. (23) to be safe for use in plant beds of azalea. Up to three applications in one season did not affect azalea transplants in tests conducted by Chappell (16). Massachusetts workers reported that CIPC at 8 lbs. per acre was as effective as bark mulch for controlling weeds in beds but that a sugar cane mulch was even more effective (54). Pridham found that granular CIPC and combinations of CIPC and sesone were effective for preventing the invasion of groundsel (*Senecio vulgaris*) in newly planted ground covers

(36). In a publication for Massachusetts nurserymen (24), Havis reported that granular CIPC has been one of the safest herbicides for use in nursery beds.

Havis also reported that granular simazine looks promising for use in nursery beds of taxus, rhododendron, laurel, and juniper (24). He points out, however, that simazine is potentially dangerous for small plants and that it should be used only on a limited scale at dosages of 1 to 1½ lbs. per acre.

Tests in nursery beds at this Station are still incomplete. In one trial, 2-year seedlings of *Taxus cuspidata capitata* were treated 6 weeks after planting into the beds. Before the herbicides were applied, the soil between the plants was stirred and the weeds were removed. The following treatments provided at least 6 weeks of residual control of weeds with no injury to the seedlings: granular simazine at 2 lbs. per acre, granular DNBP at 5 lbs. per acre, granular CIPC at 6 lbs. per acre, granular 2,4-DEP at 3 lbs. per acre, and neburon wettable powder at 3 lbs. per acre. Double dosages of the same herbicides caused injury which resulted in occasional dead plants or slight stunting.

Table 4. Weed control and plant effects after two annual applications of herbicides[1]

Treatment	Rate lbs./A.	Weeks of satsifactory weed control		Plants injured or stunted[1]	
		1958	1959	1958	1959
CIPC granules	4	4	....	Tsuga	....
	8	6	7	Tsuga	Tsuga
	12	7	8	Tsuga	Tsuga
Sesone spray	3	4	6	Tsuga	None
	6	6	7	Tsuga	None
CIPC+sesone granules	4+4	7	10	Tsuga	None
Neburon					
spray—1958	2	8	8	None	None
gran.—1959	4	10	9	None	None
NPA granules	4	5	4	None	None
	8	....	4	None	None
EPTC granules	4	4	7	None	Tsuga
surface—1958	8	4	9	Tsuga	Tsuga,
incorporated—1959					T. cuspidata[2]
Simazine granules	3	7	10+(seasonal)	None	None
	6	10	10+(seasonal)	Tsuga	Tsuga
CDEC granules					
surface—1958	6	4	7	None	None
incorporated—1959	12	....	9	....	None
2,4-DEP	4	....	8	....	None
granules	8	....	9	....	None
DNBP	5	....	9	....	None
granules	10	....	10	....	None

[1] Plants tested in 1958: Newly planted 2-year liners of *T. cuspidata, Pieris japonica,* and 2-year seedlings of *Tsuga canadensis.*
Plants tested in 1959: *T. cuspidata* established in 1958, and newly planted 2-year liners of *T. cuspidata* and 4-year seedlings of *Tsuga canadensis.*

[2] Plants established in 1958.

In another test with newly planted hemlock seedlings, however, dosages of simazine as low as 2 lbs. per acre and CIPC as low as 6 lbs. per acre depressed growth slightly but did not increase mortality. Delaying treatment from 11 days to 6 weeks after planting eliminated injury with CIPC but not with simazine. Hemlock seedlings apparently are more sensitive to these herbicides than are seedlings or rooted cuttings of yew.

Treatments applied to liners

Several pre-emergence herbicides have been tested for use in new plantings of liners, forest tree seedlings, and bulbs. Reactions of the species treated are indicated in Appendix C. A detailed discussion of the weed control aspects of the herbicides used is given in the section on *The Use of Herbicides on Established Plantings.*

Work at this Station on newly transplanted stock has involved a few of the nursery species widely grown in Connecticut — yews, andromeda, and hemlock. Results of one test conducted over a 2-year period are shown in Table 4. In both years, the herbicides were applied in early May about a week after transplanting.

All of the pre-emergence herbicides listed in Table 4 were non-injurious to newly planted liners of *Taxus cuspidata* and *Pieris japonica.* However, young hemlock seedlings *(Tsuga canadensis)* were injured by CIPC, sesone, EPTC, and simazine.

Of those herbicides reapplied the second year on liners of *Taxus cuspidata,* only EPTC at the high rate of 8 lbs. per acre depressed growth. During the second season, growth of taxus in all of the other herbicide plots was greater than growth in the partially weeded control plots, presumably because of weed control. The results of a third annual application are incomplete but no obvious injury was evident 4 months after treatment of new transplants and established plants. Assays of the soil, taken before the third season's application, revealed that only small amounts of simazine, EPTC, and neburon remained in the upper 8 inches of soil.

At several Stations (5,11,42) it has been observed that liners of *Taxus cuspidata capitata* are more sensitive to herbicide injury than other varieties of *Taxus.* The response of *T. capitata* liners to herbicides is erratic, whereas established plants of *T. capitata* are very tolerant of most pre-emergence herbicides. Delaying treatment for longer periods after transplanting might be necessary with liners of this variety.

In tests with hemlock, delaying treatment for 6 weeks after transplanting increased the tolerance of hemlock for applications of CIPC and simazine. Four-year-old hemlock liners (twice transplanted, from seed) were more susceptible to injury than 5-year-old plants (three times transplanted). Injury was avoided even with the younger plants by applying low rates of herbicide (simazine at 2 lbs. per acre or CIPC at 6 lbs. per acre) or delaying treatments for 6 weeks after transplanting.

Simazine at 2 to 4 lbs. per acre has been excellent in our tests and those of others for long residual weed control and no injury to most newly

planted yews and many other species (1,5,11,17,42,44,48). Liners of *Taxus cuspidata capitata* and certain other species have sometimes been injured by simazine at dosages above 3 lbs. per acre. With the exception of *Taxus cuspidata capitata,* yews are somewhat more resistant to simazine than forsythia, lilac, juniper, and others (42). Granular simazine has been somewhat safer than the spray formulation in newly planted stock (10,17).

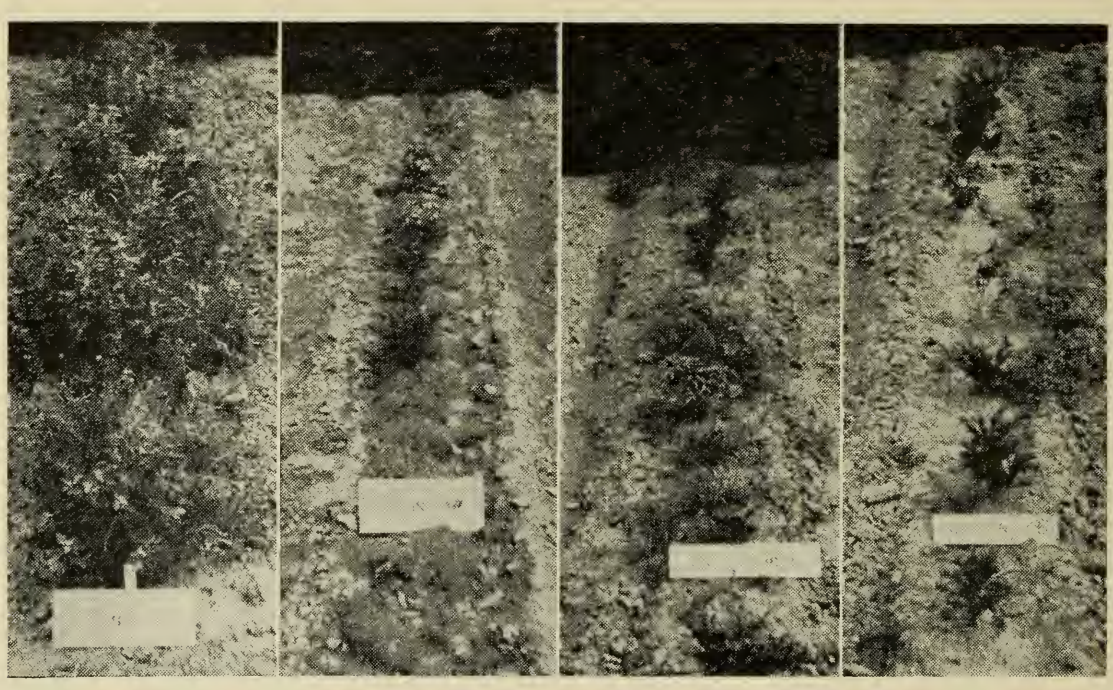

Figure 5. Results of applying granular pre-emergence materials one week after transplanting nursery liners. Pictures were taken 9 weeks after treatment. Left to right, untreated control plot, simazine at 3 lbs. per acre, sesone at 4 lbs. per acre plus CIPC at 4 lbs. per acre, neburon at 4 lbs. per acre.

Results of many tests with simazine indicate that dosages may be decreased with continued use. This may be essential to reduce the possibility of buildup in the soil. Following two annual applications at 3 lbs. per acre, however, less than ½ lb. per acre was present in the soil in the spring of the third season. This amount was sufficient to control many weeds but had no effects on taxus liners planted into the plots.

Atrazine has been tested here for only one season. The granular formulation provided long residual weed control at 3 lbs. of atrazine per acre, and there was no injury to liners of *Taxus cuspidata.* Because of its solubility, however, atrazine probably will not be as safe over a wide range of transplant species as is simazine.

Neburon has been used without injury in many newly transplanted species, sometimes at rates up to four times the normal 4 lbs. per acre (1,5,10,13,17,35,42). Neburon sometimes produces a temporary chlorosis when sprayed on foliage but this has not affected growth significantly in yews.

Diuron at 1 to 2 lbs. per acre has injured some spring plantings, even as the granular formulation (9,11). However, Pridham (37) reported that roses were unaffected by diuron alone at 4 lbs. per acre, or diuron at 1 lb. per acre plus CIPC at 4 lbs. per acre, applied about 1 month after plant-

ing. Excellent weed control was obtained. Diuron at 1 to 3 lbs. per acre also has been used without injury in pre-emergence applications on gladiolus (12). It is recommended for use on gladiolus in some states. In one test at this Station, granular diuron at 1½ lbs. per acre slightly discolored newly planted liners of *Taxus cuspidata* and provided excellent control of weeds.

Other reports from the midwest indicate that diuron can be used on conifer seedlings with little or no injury if applications are made while the seedlings are dormant, or if treatment of fall plantings is delayed until spring (47,48). However, even at low rates of application, diuron appears to be more hazardous for use in new plantings than simazine or neburon.

CIPC and sesone, alone or in combination, have been tested more widely than any other herbicides for use on newly planted species (1,5,7,-17,20,30,31). Although most woody species and some perennials are tolerant, young hemlock seedlings are sometimes affected by these compounds, as indicated in Table 4. Probably because of its solubility, sesone occasionally has injured transplants (30). The granular combination of CIPC and sesone appears to be more promising than either compound alone, because it has been more effective for the control of summer weeds.

2,4-DEP, a compound similar in chemical structure to sesone, has been used without injury in newly planted yews and hemlock seedlings, but information is lacking on tolerance of other species.

Granular formulations of DNBP, EPTC, CDEC, and NPA have been safely used in a limited number of new plantings, often at the lower of the two rates of application indicated in Table 4. DNBP has been quite useful for gladiolus plantings and is perhaps the most promising of this group for nursery liners. EPTC has injured hemlock and *Taxus cuspidata capitata* seedlings and gladiolus in some tests (1,5,12), but may be useful in some plantings where grasses present a problem.

It seems apparent that whatever the herbicide used, lower rates of application are called for in newly planted stock than in established liners or larger plants.

SUMMARY AND CONCLUSIONS

A number of herbicides have been tested for use in nursery plantings. It is fortunate that most nursery plantings, and narrow-leafed evergreens especially, are tolerant of some herbicide, applied in the right way. The nurseryman may choose among several herbicides for a particular planting and a predominant weed type, but no single herbicide has yet been developed to control all weeds in all types of nursery plantings.

Although species vary considerably in their tolerance of herbicides, plant age, degree of establishment, and the season of herbicide application also affect response of nursery plants to herbicides. The tolerance of a plant species to a given herbicide can be expected to increase as the age of the plant increases and as the time of establishment increases. In general, dormant plants are more tolerant of herbicides than growing plants. The method of herbicide application also is important. Granular appli-

cations and directed sprays of many herbicides have been safer than overhead sprays, over a wide range of plant species.

Pre-emergence herbicides are most useful for the control of annual weeds — the greatest problem for most nurserymen. These pre-emergence herbicides may be grouped according to their relative lives in the soil (the periods for which they control weeds). Simazine, atrazine, and diuron may be classed as long residual herbicides, useful for seasonal weed control in many nursery plantings. Monuron also is long-lived in the soil. However, except at low dosages, monuron probably is too hazardous for use in most nursery plantings. Simazine appears to be most useful over the widest range of plant species and degrees of establishment while atrazine and diuron find particular usefulness in established woody plantings of certain species. Atrazine is more effective than simazine for such perennial weeds as nutgrass and quackgrass, and under dry soil conditions. All three materials are suitable for use throughout the season on many woody species.

The remaining pre-emergence herbicides that have been tested in nursery plantings have shorter activities in the soil than simazine, atrazine, diuron, or monuron. These materials, including CIPC, CDEC, DNBP, EPTC, neburon, NPA, sesone, and 2,4-DEP, have been effective in controlling weeds for periods of 1 to 3 months under Connecticut conditions. If used to control weeds for the entire season, repeat applications are required, after first cultivating and removing the existing weeds. Some of these materials can be used to supplement the long residual herbicides or to control weeds in plantings not tolerant of the long residual herbicides, such as nursery beds or plantings of herbaceous perennials.

CIPC is safe for use in a wide variety of plants of woody and herbaceous perennial types. It is most effective for use during the cool seasons.

Neburon has been effective for weed control throughout the season in many woody plantings, but has been most promising for use during the dormant season.

DNBP is useful as a spray during the dormant season on some species and in granular form throughout the season.

EPTC appears promising for pre-planting treatments to control quackgrass, nutgrass, or annual weeds and for the control of annual grasses during the summer.

Although CDEC and NPA appear quite safe for use in nursery plantings, they have been more erratic in controlling weeds than most pre-emergence herbicides. Neither CDEC nor NPA offers any particular advantage over other herbicides in this group on most nursery plantings.

Sesone is safe for use in many herbaceous perennials as well as most woody plantings. Combinations of sesone with CIPC have shown greater promise than sesone alone.

2, 4-DEP can substitute for sesone, CIPC, or DNBP in many instances. It appears to be slightly more effective than sesone and CIPC in controlling weeds during the summer months.

Post-emergence herbicides such as amitrol and dalapon may be used to kill existing annual and certain perennial weeds in nursery plantings. Combinations of amitrol or dalapon with certain pre-emergence herbicides can be used to kill existing weeds and maintain long residual weed control. In this way, hoeing for the control of weeds can be virtually eliminated in some plantings.

Perennial weed pests can be controlled safely in many established woody nursery plantings, but fumigation or other treatments applied before planting are usually more desirable.

Toxic residues may injure cover crops or other crops following nursery plantings on which herbicides have been applied. When nursery plants of a similar type follow the treated plants, however, this likelihood is quite small. Even the long-lived herbicides are continually broken down or leached in the soil and when diluted further with soil in plowing, the residue problems are greatly decreased. On the other hand, repeated applications of simazine, atrazine, or diuron at high dosages each year may accelerate herbicide build-up. As weed control persists, herbicide rates can be decreased. Acceptable commercial control, rather than 100 per cent control, is the more desirable goal. Band applications contrasted to broadcast applications also delay herbicide accumulation.

The problem of herbicide effects on winter cover crops may be more of a problem to nurserymen than the effects on the nursery plants themselves. This problem can be solved by applying the long residual herbicides at reasonable dosages during the dormant seasons and later applying one of the herbicides of shorter residual activity, if necessary. Low dosages of long residual herbicides may also be useful in repeat applications.

The use of herbicides does not exclude the possibility of occasional cultivation, although cultivation may be done in a different manner. Probably the best way to use herbicides during the growing season is by band application over the row in conjunction with middle cultivation, where the soil is not thrown over the treated area. Unlike most pre-emergence herbicides, EPTC has been most effective when incorporated by shallow cultivation. Simazine also tolerates infrequent shallow cultivations in the treated area without serious harm to its effectiveness for the control of weeds.

Pre-emergence herbicides especially are affected by soil moisture and rainfall. During dry periods in the spring and summer, irrigation may be required to achieve maximum performance with an herbicide. Since the weeds also grow well under moist conditions, the grower will find that the greatest savings obtained from herbicides are in seasons of frequent rainfall.

Experiments are being continued to investigate further some of the factors affecting the usefulness of herbicides in nursery plantings.

APPENDIX A

Herbicides For Use in Nursery Plantings

The herbicides are listed according to their primary uses, as pre-emergence herbicides, post-emergence herbicides, or soil fumigants. The specific uses of these herbicides are discussed more fully in preceding sections. The relative tolerances of nursery plants to these herbicides, insofar as they have been tested, are listed in Appendix C. Specific instructions for the use of any herbicide material are given by the manufacturer on the package in which it is sold.

Pre-emergence Herbicides. Pre-emergence herbicides are active against weeds developing from seeds. The following herbicides are useful for this purpose:

1. **Carbamates**

	EPTC	**CDEC**	**CIPC**
Common Name:			
Trade Name:	Eptam	Vegedex	Chloro-IPC
Chemical Name:	ethyl N,N-di-n-propylthiol carbamate	2-chloroallyl diethyldithio carbamate	isopropyl N-(3 chlorophenyl) carbamate

Properties: EPTC, CDEC, and CIPC are formulated as emulsifiable concentrates and also on granules. All three compounds retain their activities in the soil against germinating weed seeds for several weeks after application. EPTC and CDEC have been more effective when applied to dry soil and incorporated (25). CIPC, on the other hand, is usually more effective if applied on moist soil and is hindered by soil incorporation.

EPTC has shown promise for controlling quackgrass and nutgrass, as well as many annual grasses and broadleafed species including chickweed, lambsquarters, purslane, henbit, and others. Control of grasses persists for longer periods than control of broadleafed weeds. Residual weed control under Connecticut conditions has lasted 6 to 10 weeks in most instances.

CDEC controls annual grasses and certain broadleafed weeds, including chickweed, henbit, purslane, and pigweed, usually for periods of 4 to 6 weeks. Grasses are controlled more effectively than broadleafed weeds.

CIPC kills established chickweed even at low rates of application and is effective as a pre-emergence herbicide against annual grasses and broadleafed weeds, including purslane, smartweed, lambsquarters, and dodder. Resistant weeds include ragweed, galinsoga, and fleabane. Henbit is controlled only at high rates of application. The miscible formulation of CIPC is toxic to nursery foliage, except during the dormant season with some species.

CDEC solutions can produce irritation of skin and eyes and proper precautions should be used in applying the material. Dosages of EPTC, CDEC, and CIPC are expressed in terms of the active ingredients.

2. Common Name: **DNBP**
   Trade Names: Premerge, Sinox P.E.
   Chemical Name: 4,6 dinitro-ortho-secondary butyl phenol

Properties: The amine salt formulations of DNBP are available in liquid or granular forms. As a spray, DNBP kills weed seedlings as well as germinating weeds by contact action. Granular DNBP is effective only as a pre-emergence herbicide. DNBP has controlled weeds for periods of 6 to 10 weeks under Connecticut conditions. Many annual broadleafed weeds and established chickweed are controlled by DNBP but grasses often invade treated areas following late spring or summer applications. Best results are obtained under moist soil conditions.

Because of their contact action, DNBP sprays are toxic to nursery foliage, except during the dormant season with some species. Although very toxic to mammals, DNBP is quite safe to use for weed control as long as care is taken to avoid inhalation of vapors or contact with the skin. The compound imparts a yellow color to skin and clothing upon contact. Dosages of DNBP are expressed in terms of the phenol equivalent.

3. Common Name: **NPA**

   Trade Name: Alanap

   Chemical Name: n-1 Naphthyl Phthalamic acid

Properties: NPA as the sodium salt is formulated as a water-soluble liquid or on granules. NPA is effective in killing germinating seeds of broadleafed weeds and grasses for periods of 3 to 6 weeks. Best weed control has been obtained when the soil was moist at the time of, or soon after, application.

NPA sprays injure foliage of some nursery plants. Dosages are expressed in terms of the acid equivalent.

4. Common Name: **Sesone**

   Trade Name: Crag Sesone

   Chemical Name: Sodium 2,4-dichlorophenoxyethyl sulfate.

Properties: Sesone is available as a water-soluble powder and on granules in combination with other pre-emergence herbicides. Sesone is inactive on foliage, but is broken down in the soil to an active form. When applied to moist, weed-free soil, sesone usually controls weeds for periods of 4 to 8 weeks. Broadleafed weeds are controlled more effectively than grasses. Dosages are expressed in terms of the active ingredient.

5. **The Substituted Urea Herbicides**

Common Name:	**Monuron**	**Diuron**	**Neburon**
Trade Name (s):	Karmex W Telvar	Karmex, Karmex DW	Kloben, Karmex N
Chemical Name:	3-(p-chloro-phenyl)-1, 1-dimethyl urea	3-(3,4 dichloro-phenyl)-1, 1-dimethyl urea	1-n-butyl-3-(3,4-dichloro-phenyl)-1-methyl urea

Properties: Monuron, diuron, and neburon are available as wettable powders or as granular formulations. They are only slightly soluble in water with solubilities decreasing in the order monuron-diuron-nebu-

ron. The wettable powder formulations require mechanical agitation to keep them in suspension and relatively high volumes of water should be used in their application (50-100 gallons to the acre).

These compounds are absorbed through the roots and possess long residual activity in the soil. Neburon controls annual weeds for periods of 6 to 10 weeks after spring applications and often for longer periods after dormant applications. Depending upon their rates of application, monuron and diuron control weeds for several months or more. At high dosages both compounds are effective soil sterilants.

Because of its low solubility, neburon, especially in the granular form, requires adequate moisture in the week following application for best results. Diuron and monuron also are aided by moist soil following application, as are all pre-emergence herbicides.

Sprays of monuron and diuron are toxic to foliage of many nursery plants.

Dosages are expressed in terms of the active ingredients.

6. **The Triazines**

Common Name:	**Simazine**	**Atrazine**
Trade Name:	Simazine	Atrazine
Chemical Name:	2-chloro-4,6-bis(ethyl-amino)-s-triazine	2-chloro-4(ethyl-amino)-6-(isopropyl-amino)-s-triazine

Properties: Simazine and atrazine are quite insoluble in water and are formulated as wettable powders and on granules. Mechanical agitation is required to keep them in suspension and relatively high volumes of water should be used in their application (50-100 gallons to the acre). Both simazine and atrazine are absorbed mainly through plant roots. Simazine, the less soluble of the two, is non-toxic to foliage of many woody nursery plants, while atrazine has activity as a contact herbicide and may be toxic to nursery foliage.

Under Connecticut conditions, simazine has controlled annual weeds for periods of several months following pre-emergence applications in the spring. Simazine also is effective against quackgrass, but does not control dandelion and bindweed.

Atrazine has shorter residual effects in the soil than simazine, although adequate for long residual weed control. It is effective for the control of nutgrass and quackgrass as well as annual weeds. At high dosages both atrazine and simazine are effective soil sterilants.

Dosages of simazine and atrazine are expressed in terms of the active ingredient.

7. Common Name: **2,4-DEP**

Trade Name: Falone

Chemical Name: tris - (2,4 dichlorophenoxy-ethyl) phosphite

Properties: Two,4-DEP is available as an emulsifiable concentrate and in granular formulations. It has been effective in the control of annual weeds for periods of 6 to 8 weeks. Two,4-DEP is inactive as applied but is slowly broken down in the soil to an active form. Moist soil conditions are essential for best results. The toxicity of 2,4-DEP sprays to nursery foliage has not been established.

Dosages are expressed in terms of the active ingredient.

Post-emergence Herbicides. Post-emergence herbicides are active against established weeds. Because of their toxic action on foliage, they must be directed to avoid hitting foliage of nursery plants except when indicated. The two compounds tested for post-emergence use in nursery plantings are given below.

1. Common Name: **Amitrol**

   Trade Names: Weedazol, Amino triazole, Amizine (a combination of amitrol and simazine)

   Chemical Name: 3-amino 1,2,4 triazole

Properties: Amitrol is formulated as a water-soluble powder and as a liquid in combination with ammonium thiocyanate (amitrol-T). It is also formulated in combination with simazine. Amitrol is systemic in action and is readily absorbed and translocated throughout the plant, causing chlorosis and inhibition of new growth. Amitrol is not absorbed through bark and is, therefore, safe for selective weed control in many woody nursery plantings. It is readily inactivated in the soil and is not effective for long residual weed control.

Amitrol is most effective when applied during active growth of weeds. Perennial weeds controlled with amitrol sprays include thistles, chrysanthemum weed, quackgrass, and others. Weeds sprayed with amitrol often die very slowly. Combinations of amitrol with certain pre-emergence herbicides result in accelerated kill of many weeds and longer residual weed control.

The addition of a wetting agent to the spray mixture may increase the kill of some weeds. Dosages are expressed in terms of the active ingredient.

2. Common Name: **Dalapon**

   Trade Name: Dowpon

   Chemical Name: 2, 2-dichloropropionic acid

Properties: Dalapon is obtainable as a water-soluble sodium salt. Dalapon is an effective grass killer and is absorbed and translocated by plant foliage and roots. Like amitrol, it is not absorbed through the bark of woody plants. It has only limited residual effect in the soil and is used primarily to control annual and perennial grasses, including quackgrass. Dalapon is most effective when applied during active growth of the weeds. Combinations of dalapon with certain pre-emergence herbicides are effective against broadleafed weeds as well as grasses and can provide long residual weed control after initial weed kill.

Although toxic to nursery foliage during active growth, dalapon has not injured dormant yews when applied overhead. Addition of a wetting agent aids absorbtion and may increase kill of weeds, but wetting agents should be avoided when nursery foliage is also sprayed or injury may result. Dosages are expressed in terms of the acid equivalent.

Soil Fumigants. Soil fumigants are used to sterilize soil temporarily before planting to kill weed seeds, plants, and rootstocks, as well as soil fungi and nematodes.

1. Common Name: **Allyl alcohol**
   Trade Names: Seed Bed Drench, Allyl Alcohol, A.A. Weed Killer
   Chemical Name: Allyl alcohol

   Properties: Allyl alcohol is obtained as a liquid, often combined with chlorinated hydrocarbons, to provide kill of soil nematodes. Used alone, allyl alcohol is effective primarily for weed control. Both the liquid and vapor are poisonous and contact should be avoided. The liquid is applied after plant bed preparation in the spring. The soil is then left undisturbed until planting 2 or more weeks later.

2. Common Name: **DMTT**
   Trade Name: Mylone
   Chemical Name: 3,5-dimethyltetrahydro-1,3-5,2H thiadiazine-2-thione

   Properties: DMTT is obtained as a wettable powder and may be applied in water or as a dust. It is applied to the prepared plant bed and mixed with the soil to a depth of 4 to 6 inches. One to 2 inches of water is then applied as a drench. At soil temperatures of 60° F., or above, plantings can be made 2 to 3 weeks after treatment. Under lower soil temperatures or very moist soil conditions, longer periods may be required.

3. Common Name: **Methyl bromide**
   Trade Names: Dowfume MC-2, Bromex, Methyl Bromide, etc.
   Chemical Name: Methyl bromide

   Properties: Methyl bromide is a gas extremely poisonous to humans. It is applied to plant beds by injection beneath an air-tight cover. The cover is removed after 24 to 48 hours and planting can be done 1 to 2 weeks later. Working the soil after removal of the cover aids in aerating the soil and dispensing the toxic gas.

4. Common Name: **SMDC**
   Trade Names: Vapam, VPM
   Chemical Name: Sodium N-methyl dithiocarbamate dihydrate

   Properties: SMDC is obtainable as a water-soluble liquid that is relatively safe to handle. It is applied to the prepared plant bed as a drench and is worked into the upper 4 or 5 inches of soil. The area is then watered heavily (7-10 gallons per 100 sq. feet) to seal the volatile gas formed. It also has been applied by soil injection. Plantings have been made safely within 2 to 3 weeks after application at soil temperatures above 60° F. At lower temperatures, longer periods may be necessary.

APPENDIX B

Methods of Herbicide Application

Herbicides may be applied in nursery plantings either as granular or spray formulations. It is important for the nurseryman to know when each may be used and how to use them correctly.

Granular Formulations. Granular formulations consist of the active herbicide incorporated on granules of attaclay, vermiculite, or other material. The granules are themselves inactive but hold the herbicides with varying degrees of force and release them in the soil.

Uses: Granular formulations provide a physical selectivity which permits the use of herbicides on plants not tolerant of spray formulations.

Granular formulations are easiest to apply and the equipment used is less complex than most sprayers. They usually provide equal or better weed control than sprays at equivalent rates of active ingredients, when applied to weed-free soil. This is especially true when soil moisture and rainfall is adequate enough following application to displace the herbicide from the granular particles. Under dry conditions or at low rates of application, however, granular formulations of the more insoluble herbicides often are less effective for weed control than sprays. This can be offset somewhat by incorporating certain granular herbicides into the upper layer of soil by cultivating following application or by irrigating. Granular formulations are not effective against most established weeds.

Equipment For Applying Granular Herbicides: Herbicide granules may be applied with the same equipment used to apply granular insecticides. Ordinary fertilizer spreaders are not adequate because amounts of materials as low as 25 lbs. to the acre may be applied. However, commercial spreaders are sold which are specially designed for the application of granular materials, as well as fertilizer.

For the smaller nurseries, a 2- or 3-ft. lawn spreader of high quality can be used very effectively either by attaching larger wheels (See Figure 6) or by mounting one or more spreaders behind a tractor. Hand dusters also can be used by enlarging the discharge hole to accommodate the granules used. Following use, a granular applicator should be washed thoroughly with water and allowed to dry. This removes the herbicide and prolongs the life of the spreader.

Calibration of Granular Applicators: Calibration of the equipment may determine whether control of weeds is satisfactory or poor and whether plant growth is normal or depressed. The following procedure can be used to calibrate a spreader. The amount of formulated material to be applied on 1/200 acre (218 sq. ft.) is computed by the following simple formula.

$$\text{Lbs. of granules per 218 sq. ft.} = \frac{\text{lbs. active ingredients/acre} \times 0.5}{\%\ \text{active ingredient}}$$

$$\text{The required distance to travel (in feet) is} = \frac{218}{\text{width treated by applicator (in feet)}}$$

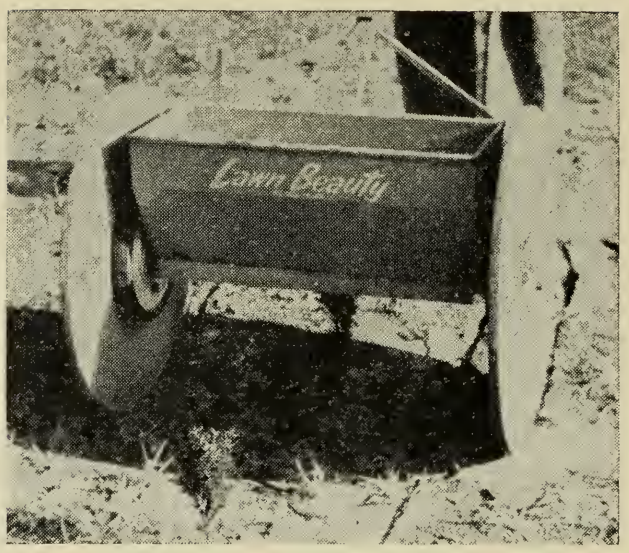

Figure 6. Lawn spreader, with large wheels cut from marine plywood, used to apply granular herbicides in the nursery.

The setting on the regulator is adjusted approximately, and the machine is moved for the required distance with a container attached to collect the granules. The collected granules are weighed and the setting is regulated by trial and error until the applicator distributes close to the desired weight of granules. The same speed should be maintained in calibration and in actual application.

Precautions: The selectivity offered by granular formulations may be lost if applied when the nursery foliage is moist. A light cloth or burlap bag dragged behind the applicator will insure that the granules fall to the ground. Calibration of the granular applicator is necessary for each granule size in order to insure accurate dosage in the field. Rates of aplication are given in terms of active ingredient per acre actually treated. The amount applied per field acre will depend upon whether band or broadcast treatments are used.

Spray Formulations. Sprays for weed control contain (a) the active herbicide, (b) spray additives or ingredients that aid the action of the herbicide, and (c) a carrier (water in nursery plantings). Commercial formulations of herbicides often include filler material which is inactive and serves merely as a diluent.

Spray additives, including wetting agents, are of several types, but have in common the action of making the spray wet the waxy leaf surface more readily and spread over the surface more uniformly. Wetting agents are sometimes added to spray mixtures of herbicides that are absorbed by weed foliage (amitrol and dalapon). Household detergents and many commercial wetting agents are available for this purpose.

Uses: Spray formulations of herbicides usually provide the cheapest means of controlling weeds in nursesies and therefore deserve serious consideration. The physical selectivity offered by granular herbicides often can be replaced by the selective application of spray materials. This may involve the use of spray materials that are non-toxic to the nursery stock being treated, or applying the sprays so that the nursery foliage is avoided,

or using certain spray materials during the dormant season. Deciduous plants, in particular, lend themselves to directed sprays because nursery foliage is easily avoided. Where weeds are established in nurseries, the use of directed sprays is often the only way to prevent hand or mechanical means of control.

Equipment for Applying Herbicide Sprays: Sprays can be applied with knapsack- or tractor-mounted sprayers. A sprayer used for insecticide application in nursery plantings can be used for the herbicides mentioned in this Bulletin if the sprayer is carefully cleaned after herbicide use. If the sprayer has a wooden tank, or if phenoxy herbicides such as 2,4-D or 2,4,5-T are used in the sprayer, separate sprayers should be used for insecticides and herbicides.

Calibration of Spray Equipment: Information is provided in Bulletin 624 on the use and calibration of knapsack and power sprayers for roadside use (3).

For most farm sprayers, calibration is a simple, but necessary procedure. With any given sprayer, one must determine the volume output of the sprayer at the speeds and nozzle pressures to be used in application. This is accomplished by the following procedure: Fill the sprayer tank with water. Drive 660 feet with the sprayer operating at the same speed and nozzle pressure as will be used in actual practice. Measure the amount of water required to fill the tank. Then compute the volume output in gal./acre as follows:

$$\text{Spray Output in gal./acre} = \frac{\text{gal. required to refill tank x 66}}{\text{spray width in feet}}$$

The desired output can be attained by varying the speed, nozzle size and pressure, as described in Bulletin 624.

The volume of spray required per acre varies with the herbicide and the application technique. However, volumes of 50 to 100 gallons per treated acre are commonly used for both pre-emergence and post-emergence spraying. In pre-emergence spraying with soluble herbicides, lower volumes can be used. The volume of spray applied in post-emergence work should be sufficient to wet the leaves of the weeds to run off.

Mixing the Spray Materials: Having determined the spray output in gallons per acre, one decides the number of acres to be sprayed and adds the herbicide and water to bring the total volume of spray to that required. Thus, the total volume of spray = no. of acres to be sprayed x gal./acre.

The amount of herbicide to add is:

(a) $$\text{lbs. herbicide per tank} = \text{acres to be sprayed} \times \text{lbs. of active herbicide per acre} \times \frac{100}{\text{percentage active ingredient in formulation}}$$

or

(b) $$\text{gals. of herbicide per tank} = \frac{\text{acres to be sprayed x lbs. of active herbicide per acre}}{\text{lbs. of active herbicide per gallon of formulation}}$$

If a band treatment is used, the number of acres to be sprayed will be less than the acreage to be covered by the equipment.

Precautions: Sprays in nursery plantings should be directed whenever possible to minimize contact between the nursery foliage and the spray. This is absolutely essential when using herbicides to kill existing weeds. Drift of toxic spray materials may cause injury on windy days. This can be minimized by spraying only in the absence of wind and using low pressures in combination with large nozzle sizes to increase droplet size. Needless to say, spray materials should be used only on species that are tolerant of them, and then only in the manner prescribed for the particular material.

APPENDIX C

Tolerance of Nursery Plants, Perennials, and Bulbs to Herbicides

The following tables indicate the reactions of various ornamental plants to granular or directed spray applications of several herbicides, as obtained from our observations and reports of many workers. The reaction of plants to overhead sprays of sesone also is indicated. The tolerances refer to established plants which have been growing in the field for one season, and to newly planted field-grown stock.

For each chemical, the range of dosages is given in terms of lbs. of active ingredient applied per acre. The code used is as follows:

S — susceptible — established plants injured by applications of herbicides at the rates given.

T — tolerant — established plants not affected by applications of herbicides at the rates given.

[1]Newly planted stock injured by treatment.

[2]Newly planted stock unaffected by treatment.

If a designation is given as S-T or 1,2, there is an indication that the plants are sometimes injured by applications at the higher rates given, but may be unaffected at the lower rates. This classification may also reflect the variation in tolerances observed by different workers. Such variation may be attributed to factors of soil type, degree of plant establishment, rainfall, and plant differences.

Some of the reactions listed are based on observations in a single trial and season. For this reason, the table is intended to act only as a guide. The commercial label of the herbicide should be consulted for further information. If a plant is not listed on the herbicide label, it should be treated with caution and only on a very small scale. Tolerance for granular or directed spray applications does not indicate tolerance for overhead sprays although, in a few instances, overhead sprays were applied.

Appendix Table 1. Tolerance of nursery plants to herbicides.

Scientific name	CDEC 6 to 8 lbs./A.	CIPC 8 to 10 lbs./A.	EPTC 4 to 6 lbs./A.	DNBP 6 to 8 lbs./A.	NPA 4 to 6 lbs./A.	Sesone 3 to 6 lbs./A.	Monuron ½ to 1 lbs./A.	Diuron 1 to 1½ lbs./A.	Neburon 4 to 6 lbs./A.	Atrazine 2 to 3 lbs./A.	Simazine 2 to 3 lbs./A.	Amitrol 1 to 3 lbs./A.	Dalapon 4 to 6 lbs./A.
Abies spp.	...	...	...	...	...	...	...	...	...	...	T	T	...
Acer platanoides	...	T	T	T	...	T	...	T	T	...	T	T	T
Alnus glutinosa	...	T	...	...	...	...	...	...	...	...	T	...	...
Azalea indicum	T[2]	T[2]	2	2	...	...	...	...	...	...	...	...	...
Azalea kaempferi	...	T	...	...	...	...	...	T	...	...	...	...	...
Azalea mollis	...	T	...	...	...	...	...	...	...	...	...	T	...
Azalea obtusum	T[2]	T[2]	S[1]	T[2]	...	S-T	...	S	...	...	...	...	...
Azalea obtusum var. Hinodigiri	...	S	S[1]	T[2]	...	T[2]	...	T	T[2]	T[1]	T[1,2]	...	...
Azalea schlippenbachi	1	2	1	...	...	...	...	...	...	...	1	...	...
Azalea spp.	T	T[2]	1,2	T[2]	...	...	...	T	S[1]	...	S-T[1,2]	T	T
Berberis spp.	...	T	T	...	...	T	...	...	T	...	T	T	...
Buxus spp.	...	T	T	...	...	1	...	T	T	...	T[1,2]	...	...
Cedrus spp.	...	...	...	...	T	T	T	...	T	...	...	...	...
Chamaecyparis juniperoides	...	...	...	...	...	...	T	...	T	...	T	...	...
Cornus florida	...	T	T	...	...	T	...	...	T	...	T	T	T
Cotoneaster spp.	T[2]	T	T[2]	...	2	2	T	...	...	...	T[2]	...	T
Crataegus spp.	...	...	...	...	...	...	...	...	...	...	T	T	...
Enkianthus spp.	T	T[2]	T	...	...	2	...	S	T[2]	T	T[2]	...	...
Euonymous altatus compactus	...	T[1]	...	...	...	...	S	...	T	...	S	...	...
Euonymous spp.	T	T[1,2]	T	...	...	2	T	...	S-T	S	S-T[1]	T	...
Fagus grandiflora	...	...	...	...	...	...	...	...	...	...	T	T	...
Forsythia intermedia	...	T	T	...	...	...	...	T[2]	T	T	S-T[1,2]	...	...
Fraxinus americana	...	...	...	...	...	...	...	...	T	T	T	...	...
Gleditsia spp.	...	T	...	...	...	...	...	...	...	T	T[2]	...	...
Hydrangea spp.	T[2]	T[2]	...	T[2]	...	...	...	S	...	T[1]	T	S	...
Ilex crenata convexa	T[2]	T	T[1,2]	T[2]	...	T[2]	S	S[1]	S-T	T[1]	T[1,2]	S-T	...
Ilex opaca	...	T[2]	2	2	2	T	...	...	S-T[2]	...	T[2]	T	T
Juniperus chinensis	T	T	T	...	...	T[2]	T	T	T	T	T[2]	T	T
Juniperus horizontalis	T[2]	T[2]	T[2]	T[2]	...	T	T	T[2]	T	T[2]	T[2]	...	...
Kalmia latifolia	...	2	2	...	...	...	...	...	...	...	T[2]	...	...
Leucothoe catesbaei	...	T	T	...	...	T[2]	...	T[2]	T	T	T[2]	...	...
Ligustrum spp.	T[2]	S-T[1,2]	T[2]	T[2]	T	T	...	T[1,2]	T[1,2]	S-T[1]	S-T[1,2]	...	...
Lonicera spp.	...	...	...	...	...	2	...	...	T	...	S	...	...

Appendix Table 1. Tolerance of nursery plants to herbicides (concluded).

Scientific name	CDEC 6 to 8 lbs./A.	CIPC 8 to 10 lbs./A.	EPTC 4 to 6 lbs./A.	DNBP 6 to 8 lbs./A.	NPA 4 to 6 lbs./A.	Sesone 3 to 6 lbs./A.	Monuron ½ to 1 lbs./A.	Diuron 1 to 1½ lbs./A.	Neburon 4 to 6 lbs./A.	Atrazine 2 to 3 lbs./A.	Simazine 2 to 3 lbs./A.	Amitrol 1 to 3 lbs./A.	Dalapon 4 to 6 lbs./A.
Magnolia spp.	...	T	...	...	...	2	...	...	T	...	...	T	T
Mahonia aquifolium	...	...	...	...	...	2	...	...	T	...	T	...	...
Malus spp.	...	T[2]	T[2]	2	1	T[2]	T	T	T[2]	T	T[2]	T	T
Philadelphus coronarius	...	T[2]	T	...	T	T[2]	...	S	T[2]	S	S-T[2]	...	...
Picea spp.	...	T	T	...	T	T	T	T[1]	T	...	T	T	T
Pieris japonica	T[2]	T[2]	T[2]	...	T[2]	T[2]	...	S-T[2]	T[1,2]	T	T[2]	T	...
Pinus spp.	...	T[2]	T[2]	2	T[2]	T[1]	T	T[1]	T[2]	T	T[2]	T	T
Platanus occidentalis	...	T	T	...	...	...	...	T	...	T	T	T	...
Populus spp.	...	T	...	...	...	...	...	T[2]	...	...	...	...	...
Prunus spp.	...	T	T	...	...	2	T	...	T	...	T	T	T
Pseudotsuga taxifolia	...	...	T	...	T	T	T	...	...	...	T	...	T
Pyracantha duvallii	...	...	...	...	...	2	...	...	T	...	1	T	...
Quercus spp.	...	...	...	...	...	T[1]	...	...	...	...	T	T	T
Rhododendron Boule de Neige	2	2	1	...	...	...	...	...	...	...	2	...	...
Rhododendron carolinianum	...	T	...	...	...	T	T	T	...	T	T	...	...
Rhododendron catawbiense	...	T[2]	T[2]	...	...	T[2]	...	T[2]	T[2]	T	T[2]	...	...
Rhododendron roseum elegans	...	...	...	...	...	...	...	T	...	S	T	...	...
Rosa spp.	...	T[2]	T	T	...	T	...	T[2]	T	T	T[2]	T	S-T
Rosa rugosa	...	...	...	...	...	...	...	...	...	...	S	...	...
Spiraea filipendula	...	T	T	...	...	...	...	...	T	...	...	...	...
Syringa chinensis	T[2]	T	T[2]	...	T[2]	T[2]	...	1	T	S	T	...	...
Taxus baccata dovastoni	T	...	T	...	...	...	...	...	...	...	T	...	...
Taxus baccata repandens	...	...	...	...	...	...	...	...	...	...	T	...	...
Taxus cuspidata capitata	T[2]	T[2]	T[1]	T[2]	T[2]	T[2]	...	S-T[1]	T[2]	T	T[1,2]	...	...
Taxus cuspidata varieties	T[2]	T[2]	T[2]	T[2]	T[2]	T[2]	T	T[1,2]	T[2]	T[2]	T[2]	T	T
Taxus media varieties	T[2]	T[2]	T[2]	T[2]	T[2]	T[2]	...	T[1]	T[2]	T	T[2]	...	T
Thuja occidentalis	...	T[2]	S[1]	...	T	T[2]	T	T	T	T	T[2]	S-T	S
Tsuga canadensis	T[2]	T[1,2]	T[1,2]	T[2]	T[2]	T[2]	...	T[2]	T[2]	T	T[1,2]	T	...
Ulmus americana	...	...	...	...	...	...	...	...	...	...	T	T	...
Viburnum spp.	...	T[2]	2	...	...	...	...	...	T	...	T[2]	T	...

Appendix Table 2. Tolerance of perennials and bulbs to herbicides.

Scientific name	CIPC 4 to 8 lbs./A.	EPTC 3 to 5 lbs./A.	DNBP 6 to 8 lbs./A.	Sesone 3 to 6 lbs./A.	Diuron 1 to 1½ lbs./A.	Neburon 4 to 6 lbs./A.	Atrazine 2 to 3 lbs./A.	Simazine 2 to 3 lbs./A.
Aquilegia hybrids	T	...	...	...	...	...	...	...
Arenaria spp.	S-T[1]	...	...	T[2]	1	1	...	1
Aster spp.	T[2]	T[2]	...	T	...	...	...	1
Astilbe spp.	T	...	...	...	...	...	...	...
Camellia spp.	...	...	...	T	...	...	...	...
Chrysanthemum	T[2]	T[2]	...	T[2]	S	...	1	S[1,2]
Cimicifuga racemosa	T	...	...	...	...	...	...	...
Convallaria majallis	T[2]	...	...	T[2]	...	...	...	...
Dahlia pinnata	...	...	...	...	T[2]	...	...	T[2]
Delphinium hybrids	S-T[2]	...	...	2	2	2	...	2
Dianthus barbatus	T[2]	...	...	...	...	...	...	...
Dianthus spp.	T[2]	2	...	T[2]	...	...	...	1
Doronicum spp.	T	...	...	...	...	...	...	...
Gaillardia aristata	T[2]	...	...	...	...	...	...	...
Gladiolus spp.	T[2]	1,2	2	T[2]	T[2]	T[2]	S[1]	T[2]
Hedera helix	T[2]	...	...	T[2]	1	2	...	2
Helenium autumnale	T	...	...	...	...	...	...	...
Heliopsis scrabia	T	...	...	...	...	...	...	...
Hemerocallis spp.	S	T	...	...	...	...	...	T
Heuchera sanguinea	T[2]	...	...	T[2]	...	...	...	...
Hibiscus syriacus	...	T	...	...	...	T	...	T
Hosta spp.	T	...	...	...	...	...	...	...
Iberis sempervivens	S-T[1,2]	...	...	T[2]	1	S	...	S-T[1]
Iris spp.	T[2]	T[2]	...	T[2]	2	...	S	T[2]
Leucojim aestivum	T	...	...	...	...	...	...	...
Mertensia virginica	T	...	...	...	...	...	...	...
Myosotis spp.	T	...	...	...	...	...	...	...
Narcissus spp.	T	T	T	...	T	...	T	T
Nepeta mussini	T	...	...	...	...	...	...	...
Pachysandra terminalis	T[2]	...	...	T[1,2]	T	...	T	T[2]
Paeonia albiflora	T	...	T	T	T	T	T	T[2]
Paeonia suffracticosa	S	...	...	...	...	T	T	T
Papaver orientale	...	T	...	...	...	...	...	S
Phlox paniculata	S[1]	S	...	T[2]	...	...	...	S
Phlox subulata	T[1]	...	...	2	...	...	...	...
Polygonatum multiflora	T	...	...	...	...	...	...	...
Sedum spp.	T[2]	...	...	2	1	1	...	T[2]
Trollius europeus	T	...	...	...	...	...	...	...
Tulipa spp.	T	...	...	...	T	T	S	T
Vinca minor	T[1,2]	...	...	S[1]	...	T	...	T[2]

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